channel." Experimenters are guided mainly by their own intuition and by the phenomenologists, who are highly undervalued in this debate between theory and experiment. The phenomenologists analyze the experimental information without too much prejudice from unreliable theories. They then attempt to provide guidance regarding profitable directions in the search for new knowledge. Their papers are generally criticized by nitpicking theorist referees and judged by comparison with published theoretical papers that will probably turn out to be wrong. Phenomenologists can thank Paul Ginsparg, who established the online electronic print archives at http://arXiv.org, for giving them a way to reach the experimenters who need their advice without having to deal with obnoxious referees.

Here is one small example of the problems faced in looking for clues to new physics. In 1998, I noted that decays like $D^+ \to K_S + \pi^+$ had contributions from Cabibbo-favored and doubly suppressed decays, and that this might lead to a direct *CP* violation between charge conjugate D^+ and D^- decays. The standard model says that both the favored and doubly-suppressed amplitudes depend on the same Cabibbo-Kobayashi-Maskawa matrix elements and there should be no *CP*-violating relative phase. But suppose some new physics contribution has a *CP*-violating phase. This new physics could give a direct *CP* violation between charge conjugate D^+ and D^- decays. This can be easily verified when data are available. Even if there is no effect, and no new physics theory that predicts an effect, such data provide information that can be used to constrain future new physics models.

When I suggested this idea to my experimental friends, the response was, "Interesting! Too bad you didn't tell us sooner. It would have been trivial to check this at the early stages of our experiment, but now it will involve remounting many tapes and a lot of work and expense. We cannot justify that without a good theoretical reason." I wrote up my suggestion and put it on the Web as http://arXiv.org/abs/hep-ph/9810375. I tried to tell all my experimental friends who were planning future experiments so that they could test this and similar ideas in time. Of course I never sent the paper for publication. At my age I don't need the credit, and I have no patience for ridiculous arguments with referees.

Today, progress in particle physics depends on the work of postdocs who analyze the tremendous amount of data accumulating at accelerators, and who must establish some record to get future jobs. They need input from good phenomenologists who can point them in profitable directions. Theorists are only marginally useful.

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Kepler's Singular Harmony

In George Gibson and Ian Johnston's article on the physics of music (PHYSICS TODAY, January 2002, page 42), box 2 on Johannes Kepler's "The Harmonies of the World" contains two interesting errors. Because a final *s* on a Latin word normally designates a plural, at first glance the title of Kepler's *Harmonices mundi libri V* suggests the translation "harmonies." However, Kepler was being erudite, taking harmonice as a Greek word and giving it the Greek genitive singular ending. Because he passionately believed in the unity of the cosmos, he used the singular form; for him the title was *Five Books on the Harmony of the World*.

In book 5, chapter 3, Kepler stated his newly discovered harmonic law as the constant proportion between the cube of the planet's mean distance from the Sun and the square of its period. Concerning his "wonderful speculations," he wrote in his preface to book 5,

> I yield freely to the sacred frenzy; I dare frankly to confess that I have stolen the golden vessels of the Egyptians to build a temple for my God far from the bounds of Egypt. If you pardon me, I shall rejoice; if you reproach me, I shall endure. The die is cast, and I am writing the book—to be read either now or by posterity, it matters not. It can wait a century for a reader, as God himself has waited six thousand years for a witness.

Incidentally, Kepler did not call that harmonic relationship a "law" or single out three particular relationships. The idea of a "law of nature" was introduced into English when Robert Boyle used the expression decades later. "Kepler's laws" were apparently first selected and numbered by the French astronomer Joseph-Jérôme de Lalande in his *Abrégé d'astronomie* of 1774.

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New Era for Physics Includes Outreach

I recognize that a great deal of work went into the Physics Survey Overview Committee's report *Physics in a New Era: An Overview*, which was discussed by Thomas Appelquist and Donald Shapero (PHYSICS TODAY, November 2001, page 34). However, I am disappointed by the generalities and platitudes in the recommendations. There can be little disagreement with any of them, but I wonder if we needed to expend all the time and money to come up with just these. Such reports have little more result than has come from congressional hearings to eradicate drug smuggling or to improve Scholastic Aptitude Test scores in high schools.

A major problem confronting society is the lack of knowledge among the public as to what science is, what constitutes scientific thinking and analysis, and what science's criteria are for determining the correctness of statements about the phenomenological world. Given this lack of knowledge, it is not surprising that pseudoscience, antiscience attitudes, and calls to return to medieval, anthropocentric, and scriptures-based worldviews abound. There needs to be a carefully considered plan of action to promote science and to inculcate appreciation for, and sensitivity to, science as a cultural enterprise that is beyond laboratories and the intellectual ivory tower of academic seclusion.

As is done occasionally with public service messages about charitable acts, respect for other cultures, and tolerance to all nonhurtful belief systems, the basic results and worldviews of science and scientists could be shown briefly on TV screens during commercial slots of popular shows. One can learn from Madison Avenue in this context. If we can

spend millions of dollars to convince the Islamic world that we oppose terrorists and not the peaceful religion of Islam, it is worth spending money to excite the public about science.

Along with religious values, traditions, and sensitivities, one may also teach children in places of worship (churches, synagogues, temples, mosques) about the human body and stars, about magnets and free fall, about the magic of numbers and symmetries. Scientists and teachers could help develop such science units for Sunday schools, where sane and civilizing values are inculcated. Newspapers could publish more frequent columns on aspects of science, present or past, especially in their children's section.

Unless we reach the general public and especially our young people, science can never become integrated with society, and the majority may continue to have distorted views and negative attitudes regarding science.

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Thomas Appelquist and Donald Shapero report on an encouraging undertaking. Most likely readers have been exposed to this type of advice more than once in the past two decades, though probably not in such a well-organized and thought-out fashion. I commend the Physics Survey Overview Committee for its efforts. Yet, because the article's wisdom is addressed to the physics community, I am concerned that it is "preaching to the choir."

I would have welcomed inclusion of a recommendation that scientists initiate a coordinated community relations effort to inform the public of the achievements cited in the article, with future achievements similarly communicated as they are realized. This effort would be underpinned by expressions of appreciation for the community's continuing support. Informed scientists with an aptitude for public speaking would present talks on various topics to key community groups such as Lions Clubs, Rotary Clubs, chamber of commerce organizations, classrooms, and parent–teacher associations. However, without a well-designed and coordinated strategy ("remaining on message"), these talks might contain such a diversity of information as to be confusing, overwhelming, and counterproductive. The undertaking needs a champion for its implementation and sustenance. The American Physical Society may be the best candidate available to be this champion.

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APPELQUIST REPLIES: I am sympathetic to the concerns that V. Raman and J. Martinez have expressed. However, I first want to take issue with Raman's claim that the recommendations of the National Research Council Physics Overview consisted of "generalities and platitudes." In fact, the report identified six particular areas of great physics potential and made several specific recommendations. For example, our principal recommendation—that the level of federal funding relative to the GDP be returned to that of the early 1980s—is quite specific and based on extensive research and detailed arguments. This recommendation and the arguments that supported it are very much in accord with the current move in Congress to generally increase support for the physical sciences. Our recommendations on physics education focused largely on the undergraduate curriculum, but also stressed that general scientific literacy is crucial.

Both Raman and Martinez discuss scientific literacy and emphasize that much of the burden for it must be borne by the physics community. I strongly agree. The NRC committee has done some work in that area. In June 2001, the committee organized a press conference that was attended by both science and general reporters and, in July 2001, held a small symposium on Capitol Hill for members of Congress and their staff members. During the work on the Physics Overview, several committee members spoke often to both scientific and general audiences throughout the country.

Such outreach work must be an ongoing process. The American Physical Society already plays a leading role in this effort, and has many resources available. University departments, too, should do more to provide scientific outreach in their local areas. The health of the physics enterprise and the well-being of an increasingly technological society depend critically on the understanding and support of science by the general public.

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Clarification on Laser Dye Concentrations

In Physics Update for the February 2002 issue of PHYSICS TODAY (page 9), one item states, "In most dye lasers, the dye concentration cannot go above a millimole/liter without quenching the fluorescence." Subsequently, lasing at a concentration of 9 mmol/L is highlighted as an achievement by the authors.[1] It should be noted that dye concentrations of several mmol/L, sometimes up to 10 mmol/L, have been known for a long time in the field of laser-pumped dye lasers.[2]

References

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2. See, for example, C. H. Chen, J. L. Fox, F. J. Duarte, J. J. Ehrlich, *Appl. Opt.* **27**, 443 (1988).

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Corrections

August 2000, page 12—In the letter entitled "The Universe in a Glass of Beer," the date for reference 1 should be 1988.

July 2002, page 72—Ilene Busch-Vishniac's current affiliation was misreported. She is dean of the G. W. C. Whiting School of Engineering at the Johns Hopkins University. ■

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